1964

An investigation into the practical problems inherent in implementing advanced materiel management techniques

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Monterey, California: U.S. Naval Postgraduate School

AN INVESTIGATION INTO THE PRACTICAL PROBLEMS INHERENT IN IMPLEMENTING ADVANCED MATERIEL MANAGEMENT TECHNIQUES

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ADVANCED MATERIEL MANAGEMENT TECHNIQUES

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A Research Paper

Presented to

The Faculty of the Navy Management School

U. S. Naval Postgraduate School

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Management

By

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May 1964

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This work is accepted as fulfilling

the Research Paper requirements for the degree of

MASTER OF SCIENCE

IN

MANAGEMENT

from the

United States Naval Postgraduate School

AN INVESTIGATION INTO THE PRACTICAL PROBLEMS

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It may be said that management today is in transition from an art based largely on intuitive judgment to a science based on recognized and accepted principles. This transition emphasizes the need for decision rules which must be communicated to and uniformly applied by operators, in order to achieve management objectives.

Nowhere today is the need more critical nor are better decision rules more urgent, than in the materiel management field. Weapon systems have increased in number and complexity, deployment more widespread, and deliveries of supporting material more urgent. As a result, not only must more decisions be made, but they must be made faster. Materiel managers can with years of experience learn to cope with difficult decision problems, but trial-and-error learning is expensive. Advanced mathematical decision models are now and have been available. The basic problem is not development but uniform application at all echelons of management. Implementation of uniform decision rules will provide for more effective and economical supply support and enable top management to establish standards for measuring performance at all levels.

May 1964
Master of Science in Management
Navy Management School

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CHAPTER I

BACKGROUND REVIEW OF PROBLEMS ASSOCIATED WITH DEVELOPMENT AND INTRODUCTION OF ADVANCED MANAGEMENT SYSTEMS

The past fifteen years have seen a revolution in military technology characterized by increasingly complex weapon systems. The increasing number and complexity of weapon systems has severely strained the capabilities of today's inventory manager. The increasing use of revolving stock funds for procurement and resale of repair parts has put additional pressure on the inventory manager to insure that minimum levels of supply consistent with effective support are maintained. Faced with these pressures for increased effectiveness under budget constraints, inventory managers have turned to a logical and promising combination of tools, the use of advanced management techniques many of which can be programmed on modern large scale automatic data processing equipment. While this combination appears to offer the best hope for solution of the inventory manager's problem, it has generated additional and unique problems of its own. These problems are primarily of a (two-way) communication nature and can be summarized as the problem of communication between the operations research analyst (who is responsible for developing the mathematical policy) and the inventory manager who must apply the policy in reaching his decision as to how much and when to procure. There is a second critical problem which may be assigned to the systems analyst; that of designing a data input system which insures the validity of the mathematical computation underlying the computer recommendation.

The problem of communication which was mentioned above has been recognized although little has been done to date to solve the problem. Mr. Charles J. Hitch, Comptroller of the Defense Department, speaking to the Operations Research Society of Canada states the problem:

> Where mathematical models and computations are useful they are in no sense alternatives to or rivals of good intuitive judgment, they supplement and complement it. Judgment is always of critical importance in designing the analysis, choosing the alternatives to be compared, and selecting the criterion. Except where there is a completely satisfactory one-dimensional measurable objective (a rare circumstance), judgment must supplement the quantitative analysis before a choice can be recommended.[1]

The Navy Ship's Parts Control Center at Mechanicsburg has been a leading exponent of the application of mathematical models to problems of inventory control. The problem of communication has also been recognized at Mechanicsburg. A summary report given to Navy inventory managers in June, 1960, is quoted as follows:

> . . . If there is to be success, two important conditions must be met: communication and confidence. These conditions are incumbent upon both the research people and the operators.
>
> The communications is particularly serious where mathematics is involved. Research people cannot expect everybody to learn their highly technical language. There is a communications gap that somebody has to fill if anything is to come of the results of research. Unfortunately the bulk of reports are in a form which are completely indigestible by operators. I have on my desk a listing of some 3,500 projects in the field of logistics. But in talking to various Armed Forces groups on the operating level I have yet to find any evidence of implementation. Part of the fault lies with communications.[2]

The problem of communication between the research and operating levels must be recognized and solved if advanced management techniques are to be fully effective. There are several management principles

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[1]Charles J. Hitch, "The New Approach to Management in the US Defense Department," Management Science, 9:1, October, 1962.

[2]Application of Mathematical/Statistical Rules at the Ship's Parts Control Center; A report to Navy inventory managers given at NSD, Mechanicsburg, June, 1960, by CAPT S. Sherwood, SC, USN.

which must be observed. The first and foremost is a recognition on the part of top management that the mathematician, statistician, or operations research analyst can contribute significantly to the problem of inventory management. Second, there must be a continuing interchange of information between the operating and research levels, as to such things as known facts of demand and item behavior. There must be the same degree of information exchange between the analyst responsible for design of the data input system so that mathematical computations are reliable. Finally, there must be developed a communication language which can translate mathematical formulae and principles into a language which the operator or commodity manager can understand. In the final analysis it is people who make decisions effective, and without some knowledge and understanding of the mathematical principles, the manager cannot intelligently change a computer recommended decision. It is hoped that this study will help in the solution of these problems.

Before discussing some of these basic problems in detail, it may be helpful to review more general problems and background of scientific management.

We live in an era of scientific management which began with the work of Frederick W. Taylor and his associates in the latter part of the nineteenth century. There are associations which have developed from the work of scientists concerned with a variety of management problems. The problems attacked in the development of a science of management parallel those concerned with the problem of inventory control or in the broad sense the problems of supply management. The problems which have been attacked cover a vast area. Mathematical techniques either exist or are being developed for the determination of optimal policies for procurement (both how much and when to buy), distribution (where to store initially), redistribution and echeloning (what considerations govern the use or nonuse of either and just how much redistribution should be done or if new procurement should be used), and transportation, to name a few models. All of these techniques

or models have been developed using mathematical tools. The earliest developments generally involve mathematics little more complex than simple arithmetic. More recent developments involve mathematical techniques so complex that only a sophisticated mathematician can begin to understand their inner workings. It is not the intent of this paper to explore these "higher mathematics." This will be left to those who have had the necessary formal training. It is, however, the purpose of this paper to explore some of the practical problems which the techniques imply. The techniques undoubtedly can, if properly administered, produce a more effective supply operation with reductions in investment and operating funds. One of the biggest problems faced by managers is the capability to understand and to gain skill in using these advanced tools. Certainly one must become skilled in their use, for any tool if poorly used can be less effective than using no tools at all.

These skills that the supply manager must acquire differ with the particular supply management scheme to be used. The manager may have to learn how to use charts, nomographs, or even special computational techniques. With increasingly automated systems there is a necessity for managers to recognize the conditions under which the mechanized recommendation should be changed. Certainly managers will have to learn new definitions and, most important, new ways of thinking about supply. In developing safety level policy, he will learn for example that 100 per cent supply effectiveness is theoretically infeasible to attain. He may learn that something very close to 100 per cent can be attained but at an exceedingly high additional cost. Here he must apply his knowledge of economics and weigh the cost of an alternative decision. The manager must learn that a forecast is not necessarily bad when actual usage does not equal the forecast. In short, the manager is faced with a considerable amount of training if he is to attempt to implement the advanced techniques.

A word of warning is in order concerning the many logistic studies

which have been completed under contract. It may be found that not all of the people who develop and propose to implement a scientific management technique are competent practitioners. Many consultants do not have the technical personnel who can produce and help to implement the plan which is sought. It is not possible for those who lack the specialized mathematical training to adequately evaluate the competence of the consultant; therefore, a partially trained consultant's "contact man" can often "sell" the mathematically naieve supply manager an ill-conceived scheme, which is mathematically poor and, therefore, cannot accomplish what it purports to do. It then becomes essential to develop and depend on "in-house" mathematical capability for advice as to competence and eventual implementation. The Navy's Ship's Parts Control Center is an outstanding example of just such an organization. SPCC's Advanced Logistics Research Division, supported by a group of mathematically oriented programming personnel, have contributed greatly to the Navy Supply System by serving as a "proving ground" for many advanced techniques. Although initially largely contractor supported, a tremendous in-house capability has been developed in a few short years.

The experience of SPCC and others who have successfully introduced advanced inventory management techniques illustrates one of many essential conditions. One of the most important conditions is the management climate, from top level to the working level, which must exist to insure successful implementation. Management must remove the natural resistance to change which any going concern faces. Inventories or the demands placed on the supply system do not behave much differently than they did 20 or 30 years ago except perhaps in the quantity, communication media, and urgency of need. Many supply managers have demonstrated the philosophy so often interpreted as "supply hasn't changed basically and we managed supply very well before these high powered techniques, so why change now?" The manager who lives by this philosophy will almost certainly guarantee the demise of any new procedure which must

be adopted. A good manager is almost always characterized by a flexibility and inquiring nature which is really a "show me, what will it do?" attitude. It is this type of management which inevitably moves forward rapidly in adopting any technique which is shown to improve performance or reduce costs. This type of management has led the way in implementing advanced mathematical inventory control techniques.

STATEMENT OF THE PROBLEM

It is the purpose of this study: (1) to investigate several areas of materiel management which are appropriate to the application of advanced management techniques, i. e., Selective Materiel Management, Management Method Determinations, Economic Order Concepts, Variable Safety Level Policy and Military Essentiality Coding, (2) to recommend solutions to practical problems associated with implementation of these policies.

IMPORTANCE OF THE STUDY

There are literally hundreds of logistic studies which have been completed in the areas of advanced materiel management techniques. Most of these studies emphasize the theoretical development of mathematical formulae and have not been concerned with the practical problems which inevitably arise during the implementation phase. The importance of this study lies in the "highlighting" of these practical problems and in the development of recommended solutions to the problems.

DEFINITIONS OF TERMS USED

Decentralized Management. As related to item management the decision of a centralized inventory manager to assign responsibility for procurement and control to individual consumers or an intermediate echelon or stock point. The central inventory manager reserves the right to require periodic financial and or usage reports in order to reevaluate his original management decision in the light of current circumstances.

Distribution System. That complex of facilities, installations, methods and procedures designed to receive, store, maintain, distribute, and control the flow of military materiel between the point of receipt into the military system and the point of issue to using activities and organizations.

Inventory Control. Those management functions performed in the control of material resulting in such integrated action as requirements computation, procurement and production, distribution and redistribution, repair and rebuild, and disposal of obsolete or excess material from the supply system.

Inventory Control Point. An organization within the Department of Defense whose primary mission is the world-wide inventory control of assigned material. Inventory control functions are performed either by individual military service (ICP's) or Defense Supply Agency Control Points.

Inventory Fraction Codes. The application of management codes by a central inventory manager to individual supply items for the purpose of applying varying degrees of management emphasis. The codes are normally representative of varying issue, sales rates, or special programs.

Operating Level of Supply. The quantity of material required to be on hand to meet replenishable issue demands during the interval between the arrival of successive replenishment shipments.

Safety Level of Supply. The quantity of material, in addition to the operating level of supply, required to be on hand to permit continued operation in the event of minor interruption of normal replenishment or variation in demand rates.

Procurement Cycle (PC). The time interval between successive procurements sometimes referred to as "Operating Level." The procurement cycle and operating level (expressed in terms of time rather than units) are synonomous only when one delivery is involved in a procurement.

Procurement Lead Time (PLT). The time interval between the initiation of procurement action and the receipt into the supply system of material purchased as a result of such action. It is composed of two principal elements, administrative lead time and production lead time.

(a) Administrative Lead Time (ALT). The time interval between initiation of procurement action and letting of a contract or placing of an order.

(b) Production Lead Time. The time interval between the placement of a contract and receipt into the supply system of material acquired.

Reorder Point (ROP). That point at which time a stock replenishment requisition would be submitted to maintain the predetermined or calculated stockage objective. The system reorder point is the sum of safety level and procurement lead time.

Retail Stocks (as differentiated from Defense Supply Agency wholesale stocks). Material which is financed by individual military department stock funds for issue to consuming units. Wholesale stocks are initially financed with Defense Stock Funds and ultimately reimbursed from military department stock funds.

Standard Unit Price. The per item issue price established and published by an inventory manager in the Federal Catalog. The maintenance of the price will be governed by such factors as volume cost to purchase, deterioration, losses in inventory, and transportation costs.

CHAPTER II

SELECTIVE MATERIEL MANAGEMENT SYSTEMS AS A MEANS OF EFFICIENTLY ALLOCATING MANAGEMENT EFFORT

One of the advanced management techniques which employs both a qualitative and quantitative approach is Selective Materiel Management. Programs have been initiated at several Navy Inventory Control Points (ICP's), within the Army, Air Force and the Defense Supply Agency (DSA). Selective Management is not a new concept. Navy ICP's have utilized fraction codes as one method of segregating inventories for selective management purposes. What is new is the recent attention given to internal reorganization along commodity rather than functional lines, and assignment of selected items for more detailed and intensive management attention. The use of mathematical and statistical concepts in analyzing the inventory, as a basis for item selection, has been extremely useful. The principles of Selective Management are simple in that with human and financial resources limited, it is most economical to allocate these resources to those items which have the potential for generating significant dollar savings. The program should also provide for support of those weapon systems which have the highest priority. In a broad sense management can be defined as the application of controls. Selective Management Programs provide for applying these controls in the most economical and efficient manner possible.

The Electronics Supply Office (ESO) and the Aviation Supply Office (ASO), Navy ICP's for electronic and aviation material, have inaugerated selective management programs. Items managed under these programs are known as Special Treatment and Review Items (STAR). The objectives of the STAR Program are quoted as follows:

(1) Apply maximum management attention to those items having greatest annual dollar demand.

(2) Assure sound investment of procurement funds.

(3) Reduce inventory investment without detriment to adequate stock availability.

(4) Provide for a flexible base to absorb periodic funding deficiencies while maintaining overall operational stability.[3]

The ESO program has identified some 150-200 items within the criteria of a minimum annual sales rate of $60,000. Included are those items which are closely connected to an existing STAR item requiring a similar management method. Although it is not evident from the procedure it has been determined that the ESO STAR Program involves management by a team consisting of approximately two civilian and one officer manager for approximately 167 items.[4]

Specific criteria are not available for the ASO STAR Program, nor does there exist a standard procedure for all Navy ICP's.

The Air Force program for Selective Management emphasizes the segregation of their inventory by unit price into High, Medium and Lo Value categories with varying management techniques.

The Army has initiated a Selective Management Program based primarily on future expected dollar sales.[5] This program is essentially the same as STAR with more refined management controls established for different levels of annual dollar demand.

The Defense Supply Agency has initiated a comprehensive study and plan for implementing selective management procedures.[6] The

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[3]ESO Internal Instruction 4440.57 Subject: Star Item Management dated 4 January, 1963.

[4]Record of telephone conversation between CAPT Tolson, DESC, and LCDR Morrow of 3 May, 1963.

[5]Army Regulation 710-45 Subject: Supply Control Policies and Procedures for Minor Secondary Items and Repair Parts, dated 15 October, 1962.

[6]Defense Supply Agency Material Management System Requirements Study dated July, 1963, pp.13-34.

objectives of the DSA Selective Materiel Management Program, in addition to provision for increased effectiveness and economy, is to standardize procedures which are to be implemented at each of its Supply Centers.[7] The most important elements in the DSA Study are a stratification of the inventories of each of the Centers into specified ranges of dollar value of annual sales. Table I indicates the number of items each Defense Supply Center is managing. The items are grouped in the ranges of annual sales from $.01-$1,500, from $1,500-$10,000, and over $10,000. An important point to note is the extremely large number of items in the Lo-Value Range and their small contribution to total sales.

In the Lo-Value area ($.01-$1,500 VAD) it is noted that almost 90 per cent of the total items managed contribute only about 5 per cent of total sales. This phenomena has been described as a "typical inventory pattern" implying that management effort, hence human and financial resources, should not be concentrated on the large number of items that account for a very minor part of total dollar sales. In the case of the DSC's, it is interesting to note that less than 3 per cent of the total items managed contribute 86 per cent of total dollar sales. Sound economic reasoning alone would indicate that management attention should be directed to this area where a major part of procurement dollars are expended.

The DSA study also recognizes factors other than annual sales which should be considered in selecting items for intensive management. These items are designated VIP (Very Important Items) items and have the following characteristics:

(1) Items with a history of a frequent out of stock position.

(2) New items being introduced into the system which because of high cost or importance must be reviewed at more frequent intervals.

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[7]Defense Supply Agency Regulation Number 4140.6 Subject: Selective Material Management Program dated 4 September, 1962.

(3) Items with high unit cost and/or high annual demand.

(4) Items highly essential to a particular mission or weapon system.[8]

In analyzing the DSA Study it is not only important to note the role played by Economic Order Quantity (EOQ) but especially the standardization of policy. A standard EOQ application has been specified for items in the Lo-Value Range ($0-$1,400 annual sales). This application results in economic procurement cycles ranging from a minimum of 12 months to an upper limit constrained to 48 months. Normally these items will be procured under informal purchase procedures. For items having greater than $1,400 annual sales, where EOQ would dictate a procurement cycle of less than twelve months, the method and frequency of procurement is to be determined by individual analysis. For these items emphasis is on the method of procurement. Selective review and analysis of each item will result in a selection of one of several types of formal procurement methods available to the contracting officer, i. e., Indefinite Delivery or Quantity, Requirements, or Annual Buys.

There is one additional area which is particularly significant to DSA and is in fact equally significant for any ICP. That is the area of items which have no recorded usage. DSA has found that more than 200,000 items, representing approximately 33.5 per cent of the total items managed, had no recorded issues.[9] Many of these items are either new in the system, are of an insurance nature, terminal (subject to phase-out), or non-standard items. A vigorous program of individual item review and analysis is necessary to identify and purge from the system those items which do not warrant retention. The various programs

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[8]DSA MMS Requirements Study, op. cit., p 33.

[9]Ibid, p 31.

being carried on to develop military essentiality coding will be of great value in assisting in this determination.

The above discussion of selective management programs has outlined criteria which are useful to the managers in selecting items for varying degrees of attention. The rules, however useful for this purpose, must be supplemented by additional study of how best to reorganize the commodity management group to make the best use of available human resources. In developing these criteria it will be recognized that the problem is primarily one of qualitative rather than quantitative analysis. While prudent management would dictate assignment of the Hi-Value most critical and difficult items to manage to the most competent item manager, what is needed is a more definitive decision rule on which this assignment can be made. This is the practical problem faced by management. It is a fact of life that this is a formidable task, for in reality, many of the techniques of selective management are still in the formative stage. The techniques cannot be fully evaluated in terms of workload impact until applied.

In applying management effort to the Lo-Value area of the inventory, the sheer weight of numbers of items alone suggest that human effort be minimized and mechanized effort be substituted. This technique implies as its ultimate goal completely automated review and replenishment of stocks on the basis of economic order quantities and variable stock levels. Obviously this goal will require a great deal of system design and effort to insure that the mechanically prepared procurement document can be accepted by management. Until such time as this automated system is reliable, it will be necessary to devote human resources and manual effort to insure effective control. The ASO has developed and is now testing an Automated Procurement System for its Lo-Value items as a part of its Management Improvement Program.

The nature of the selective management approach requires that a greater part of the total management effort will be devoted to that portion of the inventory representing the greatest dollar sales and

to those items requiring special treatment. Realizing that this approach requires intensive management, what are some specific actions which should be taken by commodity managers? First, and most important, is the establishment of a real team effort to develop more economical methods of management. This effort will require the closest coordination of all elements of the inventory manager organization. Not only should a "one best" method of procurement be developed, but intensive efforts in the technical area should result in standardization and simplification studies which will trim the inventory to a minimum number of required items. It may be pointed out that these are the normal functions of existing ICP's, however, Selective Management requires a much more intensive effort among all the working divisions. As an example, commodity managers must sit down with their counterparts in procurement and assess the economies which can result from the various types of procurement. This investigation should devulge ways to reduce operating and investment costs which are greater than simply buying under the EOQ principle.

Finally, the basic concept of selective management is that a greater degree of management should be applied to those items which have the greatest potential for generating savings. Eliminating a month of pipeline stock for the item which is selling at the rate of $100,000 a year is worth 100 times more than an item which is selling at the rate of $1,000 per year. Selective Management using annual sales as the common denominator for the normal consumption type item is a valid and justifiable method for item and personnel assignments. The development of military essentiality codes is a further refinement.

Table II outlines one method for determining the number of items to be assigned to each commodity manager. This Table was developed on the basis of the review (Procurement) cycle which is generated by the application of the EOQ formula. Specifically, it represents a breakout (refer to Table I) of the items managed at the Defense General Supply

Center. In utilizing Table II as a general guide it should be noted that any method of item assignment which is based on the value of annual sales must be modified to recognize other equally important factors. These factors which may be unrelated to annual dollar sales are such practical considerations as military essentiality, mobilization, frequency of out of stock, and related factors. Until such time as valid military essentiality coding is developed, breakout of items using dollar value of annual sales is one recommended method of item selection.

In the final analysis staff assistants can recommend a general basis for initial assignment of items under a Selective Material Management Program based on annual dollar sales. However, it should be recognized that this criteria is to be used only as an initial starting point. The test of how well any such program performs is through evaluation of performance results. Management must assign items under criteria which are of necessity largely arbitrary and then measure results. The test of the initial assignment will eventually be reflected in performance, effectiveness, and cost reduction statistics. Review and evaluation of these reports will serve to guide changes in the initial item assignment as the program develops.

As has been pointed out above, dollar value of annual sales should not be considered the sole criterion in determining item assignment and personnel requirements. However, the stratification of items by dollar value of annual sales provides a starting point in the selective management program.* Until such time as further refinements can be accomplished, such as military essentiality coding, it would seem logical and desirable to have some degree of standardization. As far as can now be determined, each Navy ICP appears to be developing and implementing its own criteria

*Recognizing that there are differences in the types of material being managed by Navy ICP's, these differences should have no bearing on dollar value of annual demand stratification.

which is not necessarily compatible with other ICP's. Since BuSandA is charged with the responsibility for central policy coordination and direction of ICP's, a standardized approach to Selective Management would enable BuSandA to better control and evaluate ICP performance. It is, therefore, recommended that BuSandA initiate a standard program for selective materiel management to be implemented at all ICP's. The program which is now under development for uniform ICP decision rules (UADP) should incorporate a standard policy for Selective Management techniques.

CHAPTER III

THE PROBLEM OF DECIDING HOW MUCH AND HOW OFTEN TO PROCURE

The problem of how much and when to procure has been the subject of numerous studies. A review of the scientific inventory control literature confirms one revealing fact, that there is really nothing new under the sun but rather an increasing knowledge and understanding of those tools already in existence. This is the case with the basic economic order quantity formula which was developed approximately forty years ago. Professor Thomson M. Whitin of Princeton University indicates that several authors are credited with development of an economic purchase quantity formula during the years 1925, 1926, and 1927.[10] This formula which equates the cost of ordering stock to the cost of holding stock is usually referred to as the standard square root formula. It has also been characterized as the Wilson EOQ formula, as a result of its adaptation by R. H. Wilson to the problem of handling quantity discounts.[11] A review of additional sources which discuss the techniques of advanced inventory management systems reveal only a difference in notation symbols in discussing the basic EOQ formula.[12]

The implementation of economic order and procurement policies was directed for all the military services for consumption type items which are stocked on the basis of repetitive demand by DOD INSTRUCTION 4140.11. It is interesting to note that the formula outlined for adoption is the standard EOQ formula:

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[10] Thomson M. Whitin, The Theory of Inventory Management (Princeton: Princeton University Press, 1957), pp 31-32.

[11] Ibid, p. 36.

[12] Martin K. Starr and David W. Miller, Inventory Control: Theory and Practice (Englewood Cliffs: Prentice-Hall, Inc.1962), pp. 79-81.

$$Q = \sqrt{2\frac{AC}{H}} \quad \text{where}$$

Q is the economic order quantity in dollars
A is the annual demand in dollars
C is the cost to order in dollars
H is the cost to hold expressed as a percentage per year.[13]

Excepted from the application of the EOQ policy are those items subject to excessive deterioration, to seasonal or economical production, unit pack items, subject to storage availability, or lack of adequate procurement funds. The DOD instruction outlines specific elements of order and holding cost which are to be considered by inventory managers in developing cost to order and cost to hold parameter values.

How have the military services implemented this DOD policy? All of the military services have implemented an EOQ policy at some level of supply; however, there are a variety of plans for specific applications. The Navy implementation has been carried out primarily at the ICP's using various models. The Planning Research Corporation developed a set of mechanical stock control tables based on a study at the Naval Supply Center, San Diego. These tables were later used to convert the GA fraction (locally procured and managed general supply items) at all Navy Stock Points in 1960. The Advanced Logistics Research Division of BuSandA has monitored a number of in-house and contractor studies for development of more advanced models.

In contrast to the Navy implementation of EOQ policies at the system management level, the Army initially concentrated at the user level and subsequently converted the major consumers in 1961-62. A pilot study was conducted at the former Signal Supply Agency, Philadelphia in 1957-61, which was to serve as a model for other Army ICP's.

The Air Force has applied a modified EOQ policy termed its Economic Order and Stockage Policy at the ICP and Depot level along

[13]DOD INSTRUCTION 4140.11, Subject: Peacetime Operating and Safety Levels of Supply; dated 24 June, 1958.

with a Selective Management Program based on Hi, Medium, and Lo-Value sales ranges. It is to be noted that the application of EOQ within the various services has developed a variety of cost to order and cost to hold values in implementing these principles. This is, of course, a result of developing cost studies under very broad guidance from DOD, and to an extent, perhaps a recognition, that costs do vary with management of differing commodities. The problem of determining cost to order and cost to hold will be considered in more detail, since it is obvious that these costs really determine the basic questions of how much and how often. The development of precise cost to order and cost to hold values appear to be one of the major factors delaying the full implementation of EOQ by the services. Existing accounting systems have not provided precise cost data in order to develop the variable (incremental) order and holding costs. The Harbridge House Study for the Army and the Dunlap Associates Study for the Navy are examples of costly efforts to develop precise cost data.[14] The nature of the problem of measuring costs and their importance in relation to decision making has been discussed as follows:

> There is no general approach to the problem such that when we apply it we can be assured that we will be achieving correct measurment of costs. On the contrary, in practice we are forced to utilize whatever ad hoc methods can be discovered which seem applicable . . . Generally, it is possible to measure all the costs involved in the usual kind of inventory situation with sufficient accuracy to achieve a resolution of the inventory decision problem. We say <u>sufficient accuracy</u> because . . . the optimal course of action is not likely to be very much changed by even relatively large errors in the measurement of costs. In other words, the typical inventory analysis is not overly sensitive to reasonable errors in the measurement of costs. This fact helps to reassure us that our conclusions will be essentially correct even <u>if</u> we are unable to obtain precise cost measurements.[15]

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[14]Harbridge House, Inc. EIP Report Nr. 2 National Order and Holding Costs of the U. S. Army Signal Supply Agency, Philadelphia, dated 7 March, 1961.

[15]Starr and Miller <u>op. cit.</u>, pp. 13-14.

The basic nature and relationship of the variable costs to order and hold as formulated in the EOQ formula provide a significant degree of tolerance in estimating these costs. Figure 1 illustrates the graphical relationship between order, holding, and total costs. It can be seen that a relatively large change in order cost will not appreciably affect total costs. Table III illustrates that an order to holding cost ratio, which varies as much as 50 per cent from an assumed true ratio, results in a minimum increase in expected total operating costs.[16] It is seen that an error in the ratio of order to holding cost of from 50 per cent under to 200 per cent over assumed true, will only increase expected operating costs by about 6 per cent. This fact is explained by the relationship between the variable costs and the effect of the square root formula, which tends to greatly reduce the magnitude of error. Welch calls the square root sign a sort of "forgiveness factor."[17]

How should all of this theory affect the implementation of economic order policy from management's viewpoint? First, and most important, management should not delay installation of economic order quantity policy pending the development of elaborate and time consuming cost studies. The fact that considerable errors in estimation can be tolerated in the basic formula, plus the realization that forecasts of average demand are subject to considerable error, suggests that management should install the concept without delay. There is no question that the total operating costs associated with managing an inventory will be reduced to a practical minimum by using the economic order principle. Many studies have been made to show the savings in both investment and operating costs which can result from substituting a variable EOQ procurement cycle for the traditional fixed replenishment cycle. The basic question which management faces is to what extent the system should be standardized at various echelons of supply and among commodity groupings. The question which may be asked is

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[16] W. Evert Welch, Tested Scientific Inventory Control, (Greenwich: Management Publishing Corporation, 1956), p. 67.

[17] Ibid.

whether the costs of order and holding should be standardized or rather the system for collecting these costs. This was one of the problems faced by the DSA in consolidating and standardizing policies at the former single manager operating agencies. Information available from DSA Headquarters (Table IV) indicates the application of EOQ at four centers. The "K" value, which represents the ratio of order to holding costs, is seen to vary from 28.52 to 59.9. Illustrated are the economic procurement cycles, expressed in months of stock, which result from applying the varying K factors to an item selling at the annual rate of $900. As indicated, the economic procurement cycles vary from 11.4 to 24.0 months of stock for this item although its annual sales rate is the same at each Center. This variance results in each Center's submission of annual budget requests which are based on computed requirements for operating stocks using different EOQ factors. DSA Headquarters would undoubtedly find that it is extremely difficult to compare and evaluate these budget requirements because each request represents a different level of operating stock. In recognition of the fact that determination of the ratio of cost to order to cost to hold is at best a rough estimate, and as previously shown is not required to be a precise value, DSA Headquarters has standardized these costs for items subject to informal purchase procedures. This standardization is effected at all the Defense Supply Centers in the DSA Selective Materiel Management Program as set forth in DSA Regulation 4140.6. The actual implementation requires the use of a K factor of 37.4 applicable to all items having $1,400 or less annual sales.[18] This policy is specified for Lo-Value items under the Selective Materiel Management Program and would result in a standard procurement cycle of 15 months for the illustrated item. (Table IV)

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[18]Defense Supply Agency Letter DSAH-OM: Subject: Selective Materiel Management Program dated 18 December, 1962.

The problem of variation in implementing economic inventory policy within the military services has been the subject of a DOD-wide study under Project 65. Among the objectives of this study was the review, evaluation, and development of uniform cost elements in order to provide a common factor basis for developing economic operating levels and re-order points. This study noted in its early stages the lack of uniformity and any attempt to standardize policies in the Navy.

> There is considerable variation among Navy ICP's in their approaches to Economic Inventory Programs. There is no current Navy program to review and validate or adjust differences.[19]

Based on these findings it is apparent that the Navy has not yet fully implemented economic ordering and procurement policy as outlined in DOD Instruction 4140.11. It can be assumed that considerable research and effort has been made to develop more advanced approaches. There would appear to be much cause for concern, not only because of the amount of time it has taken to install what has been known for many years, but also the problem referred to earlier concerning the need for precise measurement of the variables involved.

From an operator's viewpoint, it is essential that he be provided with tools which now are or could be readily made available to assist him in the solution of his inventory management problems. There will always be a need for logistics research to refine and improve existing advanced techniques, but there is a pressing need for putting these techniques to work when it is known they are an improvement over historical "rule of thumb" decision rules or, at any rate, are "better" than the methods presently employed. The action taken by DSA to standardize the EOQ factor for one segment of inventory at all its

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[19]Memorandum for the Record: Subject: Project 65-Economic Inventory Programs dated 29 December, 1961, signed Walter Goldfinger, Project 65 Action Officer.

Supply Centers, not only provides DSA with a means of comparing budget and performance, but more important, provides the operator with a recognized minimum cost tool.

The current BuSandA programs for standardizing automated systems at its major ICP's and related stock points provides an opportunity to implement a uniform approach to EOQ. If this effort is unduly delayed by procurement and installation of equipment, BuSandA should act to implement uniform procedures for application in existing systems. It is to be recognized that cost differences do exist between ICP's and within ICP's between differing types of material. Primary stock points undoubtedly experience cost differences of a lower order of magnitude. However, these differences should not significantly affect development of uniform costs; therefore, it is recommended that BuSandA develop and implement standardized cost factors at the ICP and stock point level.

CHAPTER IV

THE PROBLEM OF DECIDING THE MOST EFFICIENT METHOD OF MANAGEMENT (CENTRALIZED VS DECENTRALIZED MANAGEMENT)

The problem of the level of management at which items entering the system should be managed is one which has constantly plagued inventory managers. It is only recently that the tools of operations research have been brought to bear on this problem. In essence this problem is similar to others faced by the operating manager. He is provided with a great deal of general guidance, but lacks a definitive rule for decision purposes. DOD Instruction 4140.7 of February, 1961, outlines criteria which are to be applied by inventory managers in determining whether items of supply will be centrally managed and stocked or decentralized to local activity acquisition.[20] The instruction outlines several factors which must be considered in making a management method determination. These factors require a review of the item in relation to combat essentiality, military specification requirements, requirements for maintaining mobilization stockage, deterioration and obsolescence, demand rates, availability in commercial distribution channels, and finally the method of management which is most economical to the government. The factors other than economy can generally be tested on the basis of technical, catalog, and descriptive data which accompanies the request for item establishment. It is true that probably not all such data will be immediately available and will require a good deal of concentrated effort to obtain. Two typical examples are the determination of an appropriate shelf life which may require a series of laboratory tests; the determination of commercial availability which may require joint investigation and

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[20] DOD INSTRUCTION 4140.7, Subject: Supply, Control, and Positioning of Material, dated February, 1961.

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research by the commodity manager and procurement specialist.

When all other factors governing management method have been tested the factor of economy will greatly influence a decision as to whether the item should be controlled under centralized or decentralized management. Economy of central versus decentralized management involves a comparison of the relevant costs of each management method. The question which must be answered is how much does it cost the central inventory manager to procure and hold system stocks as compared to the costs which might be expected if each requiring activity were to procure its own requirements. At the outset it must be recognized that the determination of costs, whether at the national or local level may involve a considerable error of estimation. This fact is explained by the nature of military accounting systems which are not at present compatible with the type of cost break-out required for stockage and procurement cost comparisons. Estimated costs can be useful when applied in advanced decision rules which in many cases are not critical in the actual computation. Certainly, a computation which uses estimated costs is superior to unaided, and in many cases arbitrary intuitive human judgment.

How has the Navy specifically met the problem of developing a decision rule for its ICP's to determine economy of centralized versus decentralized management? The policy of the Bureau of Supplies and Accounts is quoted as follows:

> It is the policy of this Bureau that secondary items in the Navy Supply System which are readily available from local commercial or government sources will be procured and managed locally unless management is necessary for reasons of military readiness or the items can be more economically procured through central control. The term, being readily available from local commercial sources, means that the items are derived from routine production by a manufacturer who customarily distributes his product nationally through dispersed local outlets, or that the items are produced locally in quantities sufficient to satisfy the requirements

[illegible]

of the military activities in the local area.[21]

From a practical viewpoint how does the individual ICP manager translate this broad guidance as to economy of central procurement into a workable decision rule? Here again, as in the case of Selective Management, each ICP has established its own criteria for decision making. Historically, these determinations have been made on the basis of some generally arbitrary dollar value of annual sales cut-off.

What tool can be developed to assist the manager in improving his management method decision? One method is an extension of the recognized and accepted principles of economic ordering. This concept provides an acceptable estimation of the costs of central procurement and holding and only requires an estimate of local costs for purposes of comparison and decision. Table V illustrates a mathematical formula for comparing the costs of centralized and decentralized management. First, what are the costs of central management? They are the administrative costs of purchasing and holding operating and safety stocks. Also included is the cost of the material itself, and transportation costs for first and second destination charges (included in the Standard Unit Price). What are the costs of decentralized management? These costs are the basic costs of the material and those costs associated with buying and holding the stock. Transportation costs are included in the local purchase price of the item. Two basic assumptions underlie construction of the formulae. Studies made at the DGSC indicated that two sets of cost factors were approximately equal so each was dropped from the formulae. These costs were the administrative costs of initiating and processing requisitions through the Depot system (a central management cost) and the cost to initiate a

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21Chief Bureau of Supplies and Accounts letter S14.5, Subject: Locally managed items; Information concerning; dated 11 April, 1960.

purchase action locally (a decentralized management cost). No attempt has been made to compute a holding cost locally, since holding costs would be equal at the local level regardless of the source of supply, i.e., from local purchases or by requisitioning on the ICP. The formula for total expected central management costs represents order, material and holding costs for maintenance of system stocks. It is to be noted that transportation costs for centralized procurement have been included in the standard unit price by a predetermined percentage mark-up for first and second destination charges.

Decentralized costs are thus represented by a simple formula which is the product of estimated annual demand in units of stock multiplied by an average local purchase price.

An illustrative example of applying the formula is presented in Table VI. The formula compares the centralized and decentralized management costs of an item which has an average annual system demand of 9,600 units, is procured centrally at a standard unit price of $0.25 per item and locally at an average cost of $0.40. Using an ICP order cost of $108.30 and a 15 per cent holding cost, total central costs equal $2,709.40. The decentralized costs total $3,840.00 indicating central management is more economical. The central management costs have also been expressed as a percentage of annual sales. Similarly, standard unit price and local purchase price are expressed as a percent of annual sales. This expression permits the construction of a nomograph of Centralized-Decentralized Management (Figure 2), providing a decision rule for purposes of manual comparisons by commodity managers. As pointed out in Chapter I, a major problem in the implementation of advanced decision rules is the necessity for communicating these rules to the individual commodity manager responsible for the final decision. Figure 2 illustrates the graphical representation of the formula for centralized and decentralized management costs. The insert illustrates how the manager can apply the same demand and price data used in the example in Table VI to reach a decision. The nomograph permits a manager to apply a mathematical decision rule without requiring him to fully understand the principles on which the formula is based. Given the

required input data for demand and price, he can make a decision consistent with the established policy.

The management method formulae obviously lends itself to computer application since the elements required for computation of economic procurement cycles will undoubtedly be programmed as a part of the materiel management system. The nomograph can supplement a mechanized system particularly if price or demand input data has significantly changed subsequent to the cut-off for the machine program, thus providing a tool to aid in more consistent management decisions.

The mathematical decision rule for determining the most economical method of management is an extremely useful tool for any inventory manager who must make this determination. As any advanced decision rule, the decision which results from its application is only as valid as the input data used in the computation. As mentioned before, some costs must at present be estimated since accounting systems are not geared to generate actual costs. The problem of estimating parameter costs should not defer implementation of mathematical decision rules as long as these estimations are recognized by the manager. In many cases the very nature of the interaction of costs will offset errors in estimation and will provide a basis for more rational and logical decisions.

It is recommended that the Bureau of Supplies and Accounts consider the procedure outlined above as a basis for development of a standard approach to the problem of management method determination. The principles are sound and will permit any variations in costs which may be found between ICP's. This procedure could be easily incorporated in the current BuSandA program for standardizing materiel management systems at the major ICP's.

CHAPTER V

THE PROBLEM OF ACHIEVING A DESIRED LEVEL OF SYSTEM EFFECTIVENESS

PART 1 Variable Safety Level Policies

DOD directed the development and implementation of variable safety levels in 1958:

> C. The objective of this instruction is to provide for more effective and economical operating and safety levels of supply for these types of items (minor secondary-consumable) by utilizing:
>
> 1. Economic order and procurement principles for the establishment and maintenance of optimum operating levels.
> 2. Probability principles for the establishment of safety levels which will provide required protection against an out-of-stock position.[22]

The DOD directive sets forth specific factors to be considered in calculation of safety levels for central inventory control points:

(a) Frequency of demands, (both mean and variable).

(b) Size of demands.

(c) Reliability of resupply.

(d) Mission of the supported units of activities.

(e) Military essentiality and criticality of the item.

Finally, DOD establishes a reorder point system for consumable type items (in lieu of fixed replenishment cycles) and charges the military services with the development of specific formulae for computing safety levels and values for the variables outlined above.

The military services have developed a variety of formulae and systems for introducing variable safety levels. Under the broad DOD guidance there obviously is a lack of uniformity in the systems. However, upon closer scrutiny, there are common features shared by each.

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[22]DOD INSTRUCTION 4140.11 of 24 June, 1958, *op. cit.*

It is not possible to examine each model in detail in this survey, but to develop points of similarity and examine a few of the general assumptions upon which the models are constructed. It will become apparent to anyone who launches a study of scientific inventory management systems that the introduction of variable safety levels involves decisions under risk and uncertainty. The risk involves primarily the costs and loss of supply performance which result from an out of stock position. The uncertainty involves the future unknown demand and our ability or inability to predict or forecast this demand. It becomes immediately obvious that the forecast of demand and the accuracy or error in the forecast will largely determine the need for safety stocks. It is interesting to note that one individual has launched a whole career around this single element of the requirements problem.[23] Robert G. Brown's development of statistical forecasting systems are generally basic to any of the sophisticated safety level models. The systems he proposes have progressed from a relatively simple single smoothing model to a current triple smoothing model.[24]

The traditional "saw tooth" chart (Figure 3) graphically illustrates the elements of a supply control review and dramatizes the role safety stocks play in determining supply performance. These elements have been described as elements of the procurement or requirements objective period. The particular item illustrated indicates a total requirement or procurement objective period of 15 months comprised of a 6 month operating level (assumed to be computed under economic procurement principles as described in Chapter III), a procurement lead time of 8 months (comprised of 3 months ALT, 4 months production and 1 month delivery time) and a fixed safety level of one month. The fixed safety level represents the traditional fixed days or months of stock which have been used prior to

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[23]Robert G. Brown, Statistical Forecasting for Inventory Control (New York, Toronto, London: McGraw-Hill Book Company, Inc., 1959)

[24]Robert G. Brown, Smoothing, Forecasting, and Prediction. (Englewood Cliffs: Prentice-Hall, Inc., 1963)

the concept of variable safety level policies. The reorder point is illustrated as that level of stock represented by average usage totaling 9 months, the sum of the procurement lead time and safety level. When the net inventory (stock on hand and on order less back orders) falls to this reorder level, a procurement of an Economic Order Quantity (EOQ) is initiated to replenish the system stock. It is apparent that supply performance or effectiveness is largely determined by events taking place during the period of time between the initiation of an order and the receipt into stock of that order. The critical time of exposure to stock-out occurs just prior to receipt of any given replenishment order. If deliveries from contract are delayed, if the reorder is not initiated in a timely manner, or if demand exceeds the forecast, there is a finite probability that the item will fall through the safety level to an out of stock position. The amount of safety stock (size of safety level) will determine the ability to continue to meet customer demand. The lack of stock will result in back orders and a drop in supply performance. The advantages of a variable safety level in combination with a more accurate forecast are readily apparent. Any policy which can "tailor" each item's safety stock to the expected variation in demand will improve over-all supply performance. Even more important in today's climate of limited funds, the policy will insure maximum performance per dollar of investment in safety stock. The variable safety level policy in conjunction with military essentiality codes, enables the inventory manager to provide a predetermined percentage of availability on an item by item basis.

All variable safety level models employ the principles of statistics and probability in computing predetermined levels of effectiveness. The problem in supply management parallels that of the insurance company. Like the insurance company, it is necessary to predetermine rates (levels of supply) to insure a profit (provide specified supply support) over a future time period. Statistics provide a means of measuring probable or expected variation in future demands and the laws of probability

provide a means of mathematically computing levels of stock which will provide a required percent of protection and performance. Here again the mathematical approach is not intended as a substitute for judgment:

> It provides a systematic method for calculating the effects of several variables; it is intended as an aid to judgment, not as a substitute . . . Mathematics leads to more precise ways of determining inventory levels than are possible on the basis of intuition. As soon as several variables are present in a problem, most human minds cannot readily estimate the results of their interaction; the mathematical approach is helpful in this respect.[25]

Whitin recognizes the fallacies of across the board fixed safety allowances:

> The same allowance is made for items of extreme importance as is made for items of negligible importance. It would seem sensible to have larger safety allowances for the more important categories of items and to reduce these allowances for categories of items of small importance.[26]

In reviewing the various mathematical models which have been developed in recent years, it is apparent that aside from notational differences there is general agreement concerning basic approaches to the VSL problem. For example, an analysis of the models in use at the Ship's Parts Control Center, Defense Medical Supply Center, and the IBM model are quite similar.[27] All employ the method of forecasting, termed Exponential Smoothing, developed by Brown.[28] It is not the purpose of this paper to examine the method or details of Exponential

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[25]Whitin, *op. cit.*, p. 228

[26]*Ibid.* p. 181

[27]General Information Manual IMPACT, *Inventory Management Program and Control Techniques*, 1962, (International Business Machines Corporation)

[28]Robert G. Brown, *Statistical Forecasting for Inventory Control*, *Loc. cit.*

Smoothing or other forecasting techniques. It is sufficient to note that the Exponential Smoothing Technique attempts to improve the forecast of demand over lead time by weighting most recent demand more heavily than historical demand. The use of special computational procedures permit the recognition and adjustment for trends in demand which may exist. In general, all the models reviewed measure the error in forecast of demand against actual demand, and employ a statistical distribution as a means of specifying a level of safety stock which will insure a desired percent of supply effectiveness.

There are several differences among the models as applied which are worthy of note. For example, the SPCC model which appears to be extremely sophisticated, employs not one but three different statistical distributions, i.e., the Poisson, Negative Binomial, and Normal.[29] These distributions are selectively applied on the basis of established ranges of unit demand size. The degree of sophistication provided by three different probability distributions to represent demand is questionable. The studies of R. G. Brown have shown that the distribution of forecast errors follows the Normal distribution rather closely for those items which have experienced relatively frequent demand. It is recognized that in military supply systems many items of an insurance nature are characterized by extremely low mean demand rates and high variation in demand. For these items a statistical distribution other than the normal would be more appropriate.

It is also interesting to note that the SPCC model incorporates a shortage or stock-out cost which is currently established at $50.00 plus the square root of the unit price. This feature of the model was developed prior to the establishment of Military Essentiality Codes. As pointed out in the ALRAND extract, there is some cost involved in being out of stock. The problem of assigning any realistic value to the cost

[29]Program 61-SPCC Models extracted from ALRAND REPORT 32 dated 5 April, 1963.

of being out of stock is difficult, if not impossible, from a military point of view. In the words of R. G. Brown in discussing this problem: "The stock-out cost is not known by anyone, but adjusted to give desirable results."[30] All variable safety level policies imply some stock-out cost when supplies are not available for issue when and where required. When stock-out cost is used as a parameter in the VSL formulae, the value assigned is usually manipulated to produce the stock availability desired. Therefore, a more practical approach is to establish the availability desired (expressed in terms of a risk factor) and then permit the stock-out cost to be an implicit value determined by this specified level of availability. A further refinement (and one which SPCC has suggested by use of the control knob λ2) is the establishment of the level of availability based on a military essentiality code. This will insure the highest degree of protection against stock-out for the most essential items. SPCC has developed an elaborate three digit MEC Code which apparently will serve as the basis for this approach.[31] The SPCC model also develops a computed variance in the Production Lead Time which is an attempt to recognize and adjust for an additional variable. This computation will normally be useful only for those items which are procured frequently enough to establish reliable production and delivery patterns.

The Variable Safety Level model employed by the Defense Medical Supply Center is similar to that used by SPCC with some minor differences. The DMSC model, for example, employs double exponential smoothing with trend correction. The level of availability is set at a 95 per cent confidence level for all items without regard to military essentiality or stock-out cost.[32] It is important to note that the DMSC model

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[30] Arthur D. Little Inc., Work Memorandum Number 63, dated 10 April, 1962.

[31] SPCC Internal Instruction 4440.285A, Subject: Non-Stocked Items (NSI): review, evaluation and processing of, dated 30 October, 1961.

[32] DSA MMS REQMTS STUDY Op. cit. pp. 39, 65.

calculated a variable level for each depot rather than a system-wide calculation. This approach, plus insuring a 95 per cent confidence level at each depot for each item, resulted in a higher investment, i.e., an average of four months or more. The establishment of a system computation will reduce the total VSL investment; however, the development of military essentiality coding is a more logical basis for adjusting the desired level of availability by item.

The IBM Company has developed a statistical forecasting and Variable Safety Level model which uses safety factors from the normal distribution to set a desired level of availability.[33] R. G. Brown's method of forecasting using exponential smoothing is included. The method suggested by IBM is the same as that used by the DMSC. Perhaps the really unique feature of the IBM model is the fact that many of the required programs are developed and available to the IBM equipment user. Although developed for the commercial trade, the programs should be easily adapted for use in a military inventory problem. These "canned" programs are capable of significantly reducing a normal leadtime of testing and simulation which are required in implementing advanced management systems.

PART 2 The Use of Military Essentiality Codes

Military essentiality coding is a method by which management can select those items which have a vital relationship to a particular weapon system or component of a weapon system and insure a specified level of performance of the weapon system by having the item on hand when required. The Navy has been a leader in the study of weapon systems with their related components in the development of usable and realistic essentiality codes. The extensive study conducted under contract to George Washington University has provided military essentiality codes for submarine repair parts. The SPCC, as previously discussed, has

[33]General Information Manual IMPACT *Op. cit.*

developed an elaborate three (3) digit code, which can be used in provisioning as well as stockage level decisions. The uniform automated system presently being developed for the major Navy ICP's will incorporate essentiality coding as a means of controlling the application of advanced supply and provisioning decision rules.[34] Cdr. Mills, Director of BuSandA's Advanced Logistics Research Division, suggests a method of defining states of material readiness by an analysis of mission performance.[35] This method of analysis would provide a means of assigning military essentiality codes to particular items of supply in relation to their contribution to mission performance. Cdr. Mills points out the necessity for the operator's evaluation in development of essentiality codes:

> . . . If judgment is to be exercised then it seems best to use the judgment of the people who have the most knowledge at the level in the hierarchy being considered. Thus, perhaps, the Commanding Officer is best qualified to make judgments at the system level; department heads at the sub-system level; JO's at the sub-sub system level; chiefs at the component level; rated men at the part level.[36]

H. W. Karr of the General Electric Company proposed a method of determining military essentiality of aircraft repair parts to be used in stocking flyaway kits for aircraft squadron deployments.[37] This article is an interesting example of how probability principles, space, weight, and budget constraints, and the operator's judgment, can be interrelated to provide a military essentiality code. The method proposed by Karr is a type of analysis which can be useful in developing a

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[34]Capt. S. M. Ball, SC, USN, "Automation in the Navy Supply System," BuSandA Newsletter, XXVI (April, 1963), p. 27.

[35]Cdr. H. F. Mills, SC, USN, "Military Essentiality," BuSandA Newsletter, XXVI (March, 1963), pp. 4-7.

[36]Ibid.

[37]H. W. Karr, A Method for Estimating Spare-Part Essentiality, Rand paper, p. 1064, 17 April, 1957.

code of relative essentiality as a basis for adjusting the application of the variable safety level in accordance with probable effect on mission assignment. An example of the use of military essentiality codes developed along the lines suggested by Karr is SPCC's support policy for SSB(N) related items. SPCC has specified a 95 per cent level of availability for all SSB(N) support items at NSC, Charleston, bearing the highest military essentiality coding.[38] This is a practical example of insured item support using the military essentiality code in combination with the variable safety level.

It should be emphasized that the development of essentiality codes for those items of a general support nature in relation to mission or weapon systems is a much more difficult task. For example, how can items such as common hand tools be related to a particular mission or weapon system? Although common in nature, these items, if not available when required, can have a serious effect on accomplishing a mission. The old adage "for the lack of a nail" typifies this problem. This is not to say that an effort should not be made to specify some degree of relative essentiality regardless of the commodity in question. Information available from the DGSC is an interesting example of one method of handling this problem. Research at DGSC disclosed that approximately 8,000 general supply items could be identified in some way with combat support. This research was accomplished by screening such publications as Navy Load and Allowance Lists and Army Theater Commander lists of combat essential items. Based on these lists, a tentative essentiality code was assigned ranging from a category 1 for highest degree of essentiality to a category 4 for lowest essentiality. Listings were then coordinated with the military service retail managers for their concurrence. As a result of this effort, some 19,000 items were eventually assigned essentiality codes. The codes provide a means for specifying varying levels of desired effectiveness in relation to the Variable Safety Level

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[38]RADM(SEL) Ira F. Haddock, SC, USN, "Supporting Polaris Complex Costly," BuSandA Newsletter, XXVI, 8 August 1963, p. 21.

Policy. A simulation test was completed in April, 1963, for comparing the dollar value of investment of fixed versus variable safety levels. The VSL Model was programmed so as to compute varying levels of effectiveness in relation to varying essentiality codes. Using a minimum selection critera of 12 months actual demand history VSL requirements were computed for some 16,000 items. The results are summarized below:

No. Items	Gross VSL Dollar Investment	Net VSL* Dollar Investment
16,000	$22,623,038	$5,490,581

Gross Fixed 60 Day Safety Level Investment	Net Fixed 60 Day* Investment
$22,030,766	$6,370,624

This simulation test illustrates that for the 16,000 items in question conversion from a fixed to variable safety level could be accomplished with a net reduction in total investment of approximately $900,000 when compared to a fixed 60 day safety level, andprovide an improvement in "service" for those items which have significant military essentiality. The results of this test confirm the desirability of conversion to a variable policy from a fixed policy for two principal reasons:

(1) Assuring desired item effectiveness versus an average system effectiveness.

(2) Obtaining the desired effectiveness with reduced total investment in safety stocks.

There is an assumption which may be drawn from this test which the facts will not support. That assumption is that conversion to economic inventory programs can always be accomplished with total dollar savings. This is not necessarily true. The Project 65 Action Officer, Mr. Goldfinger, points this fact out in his study:

> A popular conception is that additional dollars are required initially to install variable levels of supply. Actually, the main questions involved in the funding impact of EIP are:

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*After applying system assets

a. Where did the inventory manager start from in terms of his pre-EIP levels of supply? If his operating and safety levels were very shallow, it is likely he will want to invest more in inventories.

b. . . .

c. What "protection level," "confidence level," or other supply performance target is he setting in connection with safety levels? The higher it is, the more money it takes. Depending upon where it is set, variable safety levels can cost more than, the same as, or less than previous fixed safety levels.[39]

Mr. Goldfinger suggests that one possible solution to the funding problem is to have inventory managers employ variable levels of supply within existing funding availability with subsequent adjustments which recognize differences in mission and commodity essentiality. He goes on to point out the difficulty in evaluating the performance of EIP systems because of inability to segregate other concurrent actions, but concludes that generally simulations have been favorable to the EIP systems.

The analysis which has been made of the principles, concepts, and various models for computing variable safety levels, indicate that these advanced decision rules are superior to the traditional fixed policies. From a practical viewpoint there appears to be no reason for a delay in implementation of a standard model. There is evidence to indicate that the individual commodity manager can do a more effective job with these tools. Here again adoption of a standard model for all inventory managers will permit Bureau or Headquarters evaluation of performance and budget requests on a common basis. As in the case of the economic ordering policy (EOQ), these advanced techniques cannot be applied to all items in the inventory. For example, new items entering the system will lack

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[39] MFR Project 65---EIP Report, Loc. cit.

demand data which would permit statistical measure for computation of a valid variation in demand essential to VSL policy. The handling of insurance type items, major end items, perishable and seasonal items, all require the development of specialized handling for most efficient commodity management. BuSandA should not only prescribe a standard VSL model to be incorporated in the automated ICP and stock point programs, but must develop and specify the confidence levels it desires for each item assigned a military essentiality code. This recommendation in turn would require a common approach in the determination of military essentiality codes.

CHAPTER VI

MATERIEL MANAGEMENT PROBLEMS AT THE NAVY STOCK POINT LEVEL

The preceding chapters have discussed and recommended the implementation of advanced mathematical decision rules as an aid to more effective and economical supply support. While the primary emphasis has been given to installation of these techniques at the NICP or system level, there is equal validity to the use of these or similar techniques at the stock point level. The Navy recognized the advantages of this concept in the development of the BuSandA Stock Tables which permitted a manual computation of economic order and variable safety levels for the old GA fraction. The further implementation of these decision rules at the stock point level has been hampered by the rapid and extensive realignment of logistic responsibilities which resulted from the creation of the Defense Supply Agency. It is not the purpose of this chapter to review the many and varied problems which the creation of DSA posed for the Navy. Since becoming operational on 1 January, 1962, the DSA has, in conjunction with representatives of BuSandA and the ONM, solved many of the more urgent problems. The transition from a Navy logistic system based on program support to an integrated DOD system based on commodity (FSC) support is an accomplished fact. The transition has been accomplished within the guidance suggested by RADM Crumpacker, Chief BuSandA, who in 1962 answered the question of how the creation of DSA would affect Navy logistics:

> This is a major change in our way of doing business but not a curtailment of that business. . . We in BuSandA, in BuSandA-managed activities and in other field and fleet supply functions have our continuing mission of doing everything possible to improve support and readiness of our fleet.[40]

Superimposing a wholesale DOD-DSA supply system on the Navy's

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[40] BuSandA Newsletter Vol. XXV No. 2, "Pattern for Tomorrow . . . This is DSA," February, 1962.

[illegible]

integrated supply system has resulted in a realignment of logistic missions and responsibilities. The Navy has found it necessary to create a Navy Retail Supply Office, the Fleet Material Support Office, to establish inventory management policy for those items which were formerly managed by Navy ICP's and now transferred to DSA. The DSA has also recognized the need for changes in its original distribution system to accommodate peculiar Navy problems. The Navy has long practiced the direct support concept of positioning material in bulk quantity lots as near the consumption point as practicable. This concept involves the direct allocation of material from contract to consumption point eliminating second destination transportation and double Depot handling charges, and minimizing transportation costs by obtaining the most favorable rates on bulk shipments. The decision by DSA to establish Specialized Support Depots and Direct Supply Support Points resulted in the positioning of selected items and ranges of DSA owned material at or near the point of consumption, which not only improved supply support to Navy customers, but reduced operating costs. This decision in effect resulted in partial DSA adoption of a Navy concept which is a part of the Navy integrated supply system. Under this concept wholesale and retail stocks are stored together (in this case the Navy eliminates its need for retail stocks and draws on wholesale stocks directly). The procedure has advantages for both the Navy and DSA by minimizing stock investment, maximizing supply effectiveness, and making possible the economies inherent in direct input of material from industry to as close to the point of ultimate use as possible.

The use of SSD's and DSSP's has only partially solved one of the Navy's most perplexing problems, i. e., to substitute a "pull" from the DSA system for the former Navy ICP "push" system. The problem can be clarified in terms of a practical example. Prior to the integrated DSA management of common use general supply items, support responsibilities were centered in the General Stores Supply Office, Philadelphia. GSSO was responsible for support of general supply type items to all users in

the Navy. Under the Navy support concept, wholesale stocks were maintained at several types of supply activities, i. e., distribution points, primary, and secondary stock points. The NSC Norfolk is an example of a major primary stock point being responsible for support of all off-shore Atlantic area and European activities as well as satellited stock points. In addition, local activities including retail issues to ships were supported by Norfolk. Norfolk stocks were replenished on the basis of periodic stock status reports forwarded to GSSO which resulted in replenishment of Norfolk stocks either through redistribution or procurement action. The levels of stock maintained at Norfolk were based on stockage objectives prescribed by BuSandA.

With the creation of the Single Manager concept the general supply items were transferred from the Navy's ICP (GSSO) to the cognizant Defense Supply Center (DGSC). Prior to the implementation of the SSD and DSP distribution pattern, NSC Norfolk became a "puller", requisitioning on the wholesale system. The transfer of the bulk of the GSSO mission to DSA resulted in the disestablishment of that activity with a small nucleus of its personnel being incorporated in the former Military Industrial Supply Agency. The subsequent transfer of MISA to DSA left the Navy with an inadequate requirements computation capability for "retail" stock levels; e. g. GSSO formerly "pushed" general stores items to NSC Norfolk; the NSC was now responsible for determining "when" and in what quantities to "pull" material from DSA. The subsequent establishment and gradual operational capability build-up of the FMSO has helped to re-establish and re-assign this essential function. It was the Navy's fear that a completely centralized DSA wholesale distribution system with stocks positioned at predominately inland Army General Depots would not provide a sufficiently flexible and responsive system in order to satisfy ship turn-around time and industrial schedules in a timely manner. The principal factor which further complicated the Navy's ability to maintain adequate retail stocks was the severe limitations placed on NSF obligation authority. NSF funds were reduced in order to

provide initial working capital in the Defense Stock Fund. For these reasons the Navy proposed to DOD and DSA integration of the CONUS Navy and DSA supply distribution systems in much the same manner as integration of the wholesale and retail echelons had been effected within the Navy. The subsequent designation of some SSD and DSSP activities has provided the Navy in part with the level of supply support which is essential to the readiness of its ships and priority weapon systems. A recent brochure released by the Chief BuSandA describes in detail the negotiations between Navy and DSA representatives which resulted in the partial integration of the DSA wholesale and Navy retail systems.[41]

The brochure summarizes the Navy position as follows:

> DSA has, to a greater extent than the Navy, the resources to perform this function (supply support of fleet and major overhaul activities). DSA is composed of capable and responsible military and civilian personnel, and there is every reason to believe that DSA can and will support Navy combatant forces in an outstanding manner.[42]

The partial integration of the Navy retail and DSA wholesale supply systems by stocking DSA owned material at many Navy retail activities has provided effective support at those activities for items which have been designated for centralized inventory control and stockage. However, these procedures are only applicable to those items which are designated SSC 1 (Supply Status Code 1). As discussed in Chapter III each DSC is responsible for determining whether centralized or decentralized management is most economical to the government. When a decision is made to designate an item as warranting decentralized management current DOD-DSA procedures require that the item be offered to the General Services Administration for a management determination (refer to DOD INST. 4140.7 and DSA Regulation 4140.2). In addition special referral procedures apply to any item on which the GSA is a

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[41] Integrated Navy/Defense Supply Agency Supply Systems, Chief BuSandA letter S13.33, dated 30 July, 1963.

[42] Ibid p. 13.

registered federal catalog user. The DSA-GSA referral program has resulted in each of the DSC's offering and GSA acceptance of a sizeable number of items.[43] In addition, a decision by the Assistant Secretary of Defense (I & L) in 1963 resulted in transfer of all common Hand Tools (FSG 51) and Paints, Lacquers, and Thinners (FSG 80) to the GSA. This logistic transfer could involve from 40,000-50,000 items when completed. Items which have been designated for decentralized management have imposed an additional burden on the Navy Retail System. These items are not available through the normal DSA requisitioning channels, but must be obtained either from a GSA source (Regional Depot, Federal Supply Schedule, or National Buying Program) or from local purchase. A recent visit was made to the Naval Supply Center Oakland to explore this problem further. The Naval Supply Center Oakland is the principal Navy Stock Point for WestPac extra-CONUS demands and has assumed a DSA mission as a Specialized Support Depot. Discussion with management personnel in the Control Department was extremely revealing. These personnel are particularly concerned with the impact which the myriad of logistic transfers have had on the operating level. They pointed out that assumption of the DSA mission had required a complete reorganization of stock and receipt control personnel along DSC lines. They pointed out that additional missions had been assumed under severly limited personnel ceilings which in fact had been reduced in recent months. Personnel were particularly concerned with the volume of cognizance changes. A typical example was a recent directive from the Ordnance Supply Office requiring cognizance transfers which had not been accomplished before a second change had been received.

Discussion with the supervisor of the decentralized (SSC-2) item stock control battery revealed that approximately 26,000 items were currently managed with more than half the items procured through the GSA.

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[43]A report published by the GSA titled "Supply Support to DOD Monthly Status Report"dated September 1962 indicated that four DSC's (DGSC, DISC, DCSC, and DASC) had offered 161,122 items with GSA accepting 18,896.

An indication of the magnitude of the management problem is provided by the estimated annual sales and procurement program for these items.[44] Since the primary purpose of the visit was to explore the possible application of advanced decision rules and obtain demand data for a simulation study, the supervisor was questioned as to the present decision rules employed in managing this program. A procurement program of over $11,000,000 would appear to warrant the application of advanced decision rules. The criteria for maintaining stock levels on decentralized items is provided by the FMSO. FMSO publishes its guidance in FMSO Instruction P 4400.12 A. Part I - Introduction - outlines the apparent anamoly of the decentralized management problem:

> One of the major results of the establishment of the Defense Supply Agency and the expanded application of integrated material management has been the reversion to local inventory management responsibility of many stocks of material formerly managed by Navy inventory control points.[45]

In essence the DOD-GSA referral program resulted in a major "requirements pull" problem at Navy retail stock points for these decentralized items. Based on the NSC Oakland NSF budget for these decentralized items (SSC 2) amounting to approximately $12,000,000, it is readily apparent that the major retail stock points are responsible for a major segment of FMSO's total NSF budget.

> Stocking activities have always been responsible for the management of a portion of their inventory, and most smaller supply departments have never operated in any other way. Nonetheless, with the advent of DSA and GSA on the military supply logistics scene, the proportion of Navy

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[44] Personal correspondence between the authors and Cdr. W. N. Schneider, SC, USN, Deputy Control Department Supervisor. FMSO allotted $11,655,741 (small portion of total for local repair) supporting annual sales of $11,138,640.

[45] FMSO INSTRUCTION P 4400.12 A, Subj: Navy retail management of medical, general, industrial, automotive, construction, packaged petroleum and chemical items under cognizance symbols "91," "KZ," "9A," "9C," and "9W"; instructions for, dated October 4, 1963.

financial obligations made locally has almost tripled. Specifically, on 30 June 1960, with medical as the only single manager, approximately $100 million was budgeted for locally by stock points for procurement both of decontrolled items and for local purchase of centrally managed items. Just three years later, on 30 June 1963, approximately $270 million fell into this category.[46]

A procurement program of this magnitude would certainly warrant the utilization of the most economic and efficient supply decision rules. A review of FMSO's supply decision rules for inventory management indicates that rather than a variable economic inventory policy fixed replenishment decision rules are specified. It is understood that FMSO is presently testing a VSL Model at MCAS Cherry Point, which, if proven satisfactory, may be implemented system wide. For the computation of replenishment requirements a fixed stockage objective of five (5) months is used. The stockage objective is broken down into a three (3) months operating level, one (1) month order and ship time and a _fixed_ safety level of one (1) month. It is noted that the Instruction authorizes the use of the BuSandA EOQ Stock Tables; however, at the operator's level EOQ Tables are not being used. The stock control personnel of NSC Oakland indicated that they were not using EOQ because of lack of NSF procurement funds. The personnel also indicated that requirements studies generated by their computer invariably required manual adjustment of order quantities. These changes were caused by necessary revisions to average demand which resulted from system realignment of customer activities. Because of these changes each historical demand must be analyzed to insure its future validity. It is interesting to note that regardless of the requirements system employed (fixed or variable) computations would have required adjustment because of the changes in demand data.

It was the purpose of this visit not only to discuss advanced supply decision rules with the operators, but to obtain data on which a simulation study could be made. It soon became apparent that such a

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[46]_Supply Management Responsibility for Defense Supply Agency Items_ enclosure (1) to Chief BuSandA ltr S13.33 dtd 12 Feb 1964.

simulation was not feasible due to the changes in the basic ground rules which have occurred almost continuously since the inception of DSA. The authors reviewed several requirements computations and found that in every case the demand data on which the machine computation was based could not be accepted. Cdr. Schneider pointed out that the change in NSC Oakland's status (i. e., recent designation as a DSA SSP) had materially affected their ability to recreate transactions or run audit trails. A visit to an activity such as NSC Oakland clearly points out the problem and difficulties faced by the operator in implementing any supply decision rules. Changes imposed upon changes make it impossible to institute and evaluate supply management decision rules. This fact of life should not, however, preclude the implementation of advanced rules which are known and have been proven to be more effective and economical. Such is the case with the basic EOQ and the VSL. NSC Oakland has a substantial computer capability as do the major Navy Retail Stock Points. This capability is being increased within a few months under the Uniform ADP installation. As previously pointed out, advanced supply decision rules are particularly susceptible to computer application. The DSA & DOD decisions which have substantially increased the requirements determination for decentralized items at the Retail Stock Point level, emphasized the necessity for implementing better decision rules. This problem cannot be solved solelyby the operators. There must be guidance and assistance from a higher level. This places the responsibility firmly at the policy level, not only for the development of advanced models, but for communicating and selling their real value to the operator. Too often EOQ is lightly dismissed and placed in the category of "too expensive." The policy maker is in a position to prove to the operator that EOQ and VSL will provide the maximum effective support for each dollar invested in inventory. It must be recognized that any system of replenishment, regardless of its nature, cannot be truly effective if the basic guidelines under which it operates are constantly changing. The progress in integrating the Navy retail and DSA wholesale systems is at the point where future operations should be

less erratic. The management problem at NSC Oakland in controlling 26,000 items with the expectation of this number significantly increasing, again emphasizes the need for more effective decision rules. The Uniform ADP installation again is a logical vehicle to implement uniform advanced decision rules at all the major retail stock points. It is recommended that personnel of the FMSO coordinate this effort. There are many workable models in use today which could be adopted for implementation at the stock points. Several of these models have been reviewed and discussed in the preceding chapters of this paper.

TABLE I

PERCENTAGES OF ITEMS AND DOLLARS IN ANNUAL DEMAND RANGES BY DSC

	$ .01 - $1,500				$1,500 - $10,000				Over $10,000			
	Items	%	Dollars	%	Items	%	Dollars	%	Items	%	Dollars	%
DASC	12,545	91.9	2,618,261	23.5	808	5.9	3,243,581	29.1	302	2.2	5,294,227	47.4
DC&TSC	5,064	47.8	1,952,194	0.4	2,909	27.5	12,296,271	2.8	2,618	24.7	424,893,181	96.8
DCSC	51,348	90.3	9,757,541	11.8	4,499	7.9	16,232,622	19.7	1,024	1.8	56,476,632	68.5
DESC	231,259	93.9	37,433,916	17.6	12,351	5.0	42,729,709	20.1	2,775	1.1	131,936,744	62.2
DGSC	22,418	81.1	5,161,030	4.1	3,568	12.9	13,633,000	10.9	1,645	6.0	106,468,000	85.0
DISC	51,278	88.2	8,411,994	7.5	4,987	8.6	19,390,815	17.3	1,892	3.2	84,391,134	75.2
DMSC	3,181	49.9	1,457,200	1.4	1,796	28.2	7,534,700	7.3	1,398	21.9	93,895,200	91.3
DPSC	154	47.4	81,000	1.0	80	24.6	335,000	4.1	91	28.0	7,686,000	94.9
DSSC	1	0.4	1,000	--	7	2.7	35,000	0.03	253	96.9	162,882,000	99.97
TOTALS	377,248	89.8	66,874,106	5.3	31,005	7.4	115,430,698	9.2	11,998	2.8	1,073,923,118	85.5

[illegible]

[illegible]

[illegible]	[illegible]

[illegible]

TABLE II

ITEM MANAGEMENT ASSIGNMENT
(Based on Dollar Value Stratification and Economic Procurement Cycles)

Dollar Value Sales	Avg PC	Avg Orders per year	Items per item Manager	No. of item Managers	Hours Available Per Item*	Total Items Managed
Over 1,000,000	3	4	2	5	904.0	10
500,000-1,000,000	3	4	6	2	301.3	12
100,000-500,000	3	4	20	10	90.4	200
50,000-100,000	3	4	40	6	45.2	240
10,000-50,000	6	2	100	12	18.1	1200
5,000-10,000	10	1.2	150	7	12.1	900
2,500-5,000	7½	1.6	200	7	9.0	1400
1,500-2,500	10½	1.4	250	5	7.2	1250
1,000-1,500	13	0.9				
500-1,000	17	0.7				
200-500	25	0.5	400	58	4.5	23200
100-200	38½	0.3				
Less than 100	48	0.25	Subject to automated procurement			
				112		28412
					Inactive	11793
					Total	40205

*Working days per year 5 X 52-8 (holidays) - 26 (leave) = 226

226 working days X 8=1808 workhours per year

TABLE III

THE EFFECT OF ERRORS ON TOTAL COST

If Order, Holding or Ratio of Order to Holding Cost is this % of correct	The EOQ will be this % of correct	And the Added cost will be
25%	50%	25%
50%	71%	6%
100%	100%	0%
150%	122%	2%
200%	141%	6%
300%	173%	15%
400%	200%	25%

TABLE IV

COMPARATIVE "K" VALUES

Activity	"K" Value	$Q = K\sqrt{A\$}$ $PC(MOS) = \frac{Q\$}{AMD\$}$ Annual Sales = \$900
DESC	28.52	11.4 months
DMSC	59.9	24.0
DGSC	39.5	15.8
DISC	37.77	15.1

DGSC - \$117 less 10% = \$105.30; K = 37.47

DSA	37.47	15.0 months

$(37.47)^2$ gives EOQ \$1404; PC = 12 months

\$1400 annual sales or less = low value EOQ program.

TABLE V

CENTRALIZED - DECENTRALIZED MANAGEMENT COSTS

UPC	= Estimated unit price - Centralized management	D	=	Annual demand in units
UPD	= Estimated unit price - Decentralized management	H	=	Holding cost rate
PC	= Order quantity in months of supply	B	=	Cost to procure
SL	= Safety level in months of supply			

ANNUAL CENTRALIZED MANAGEMENT COSTS - TEC (C)

TEC (C) = Order Cost + Holding Cost + Cost of Item

$$= \frac{12B}{PC} + \left(\frac{PC}{2} + SL\right) \times \frac{D}{12} \times H \times UPC + D \times UPC$$

$$\text{Cost as \% of Sales} = \frac{TEC\ (C)}{D \times UPC} \times 100$$

ANNUAL DECENTRALIZED MANAGEMENT COSTS - TEC (D)

TEC (D) = Order Cost + Holding Cost + Cost of Item

= (See note) + (See note) + D x UPD

$$\text{Cost as \% of Sales} = \frac{TEC\ (D)}{D \times UPC} \times 100$$

$$= \frac{UPD}{UPC} \times 100$$

NOTE: The following costs are equal and therefore excluded:

From Centralized Cost		From Decentralized Cost
Requisitioning Cost	=	Cost to Procure
Cost to hold locally	=	Cost to hold

TABLE VI

EXAMPLE:

$D = 9600$ units

$UPC = \$0.25$

$UPD = \$0.40$

$H = .15$

$B = \$108.30$

$C = \text{EOQ factor} = 37.4$

$PC = \dfrac{12C}{(D \times UPC)^{1/2}} = 9$ months

$SL = 1$ month

ANNUAL CENTRALIZED MANAGEMENT COSTS TEC (C)

$$TEC(C) = \frac{12B}{PC} + \left(\frac{PC}{2} + SL\right) \times \frac{D}{12} \times H \times UPC + D \times UPC$$

$$= \frac{12 \times \$108.30}{9} + \left(\frac{9}{2} + 1\right) \times \frac{9600}{12} \times .15 \times \$0.25 + 9600 \times \$0.25$$

$$= \$144.40 + \$165 + \$2400$$

$$= \$2709.40$$

$$\text{Cost as \% of Sales} = \frac{\$2709.40}{\$2400} \times 100 = 113\%$$

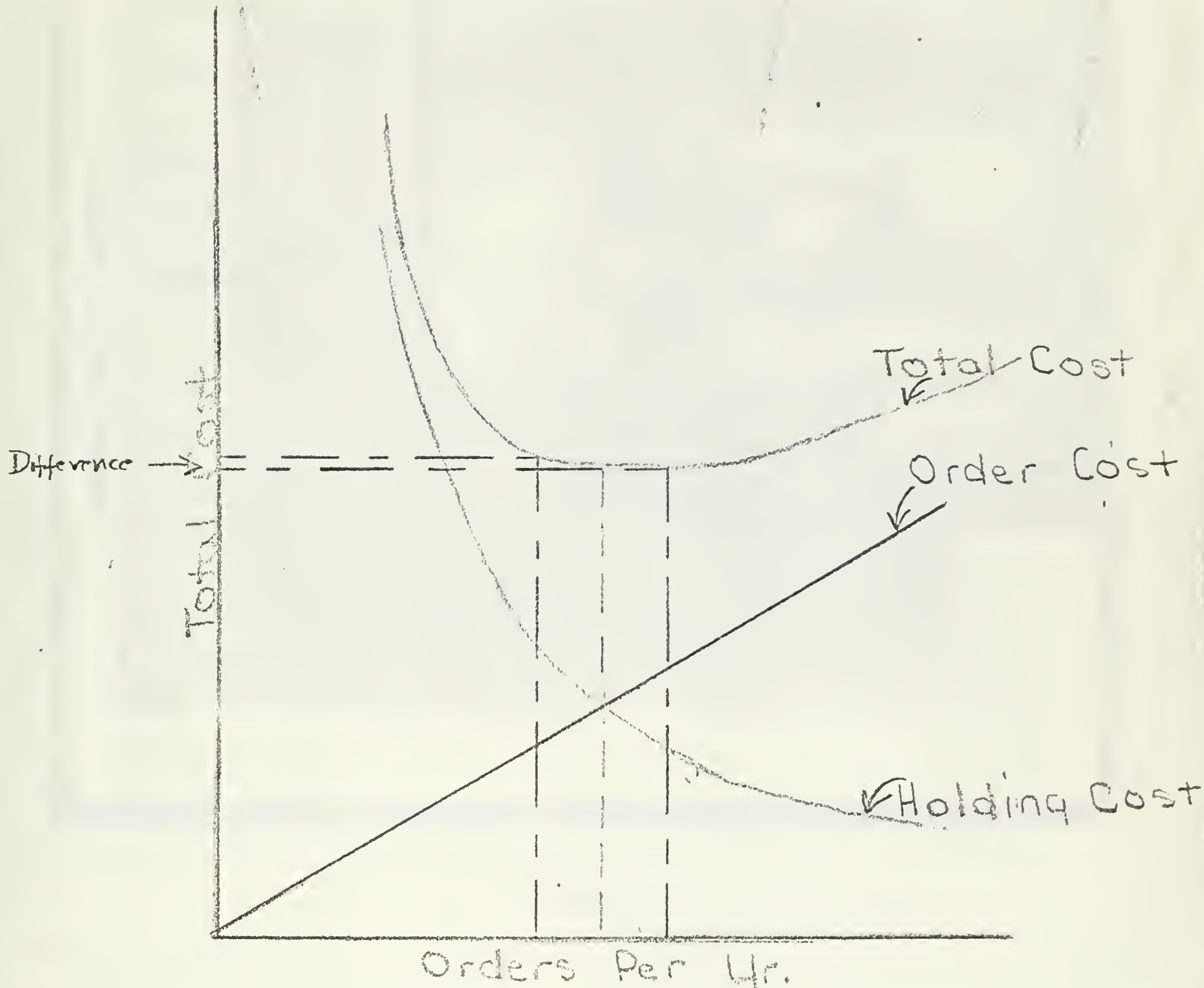
ANNUAL DECENTRALIZED MANAGEMENT COST TEC (D)

$$TEC(D) = D \times UPD$$

$$= 9600 \times \$0.40$$

$$= \$3840$$

$$\text{Cost as \% of Sales} = \frac{\$0.40}{\$0.25} \times 100 = 160\%$$



(True Order|Holding Cost)

Figure 1

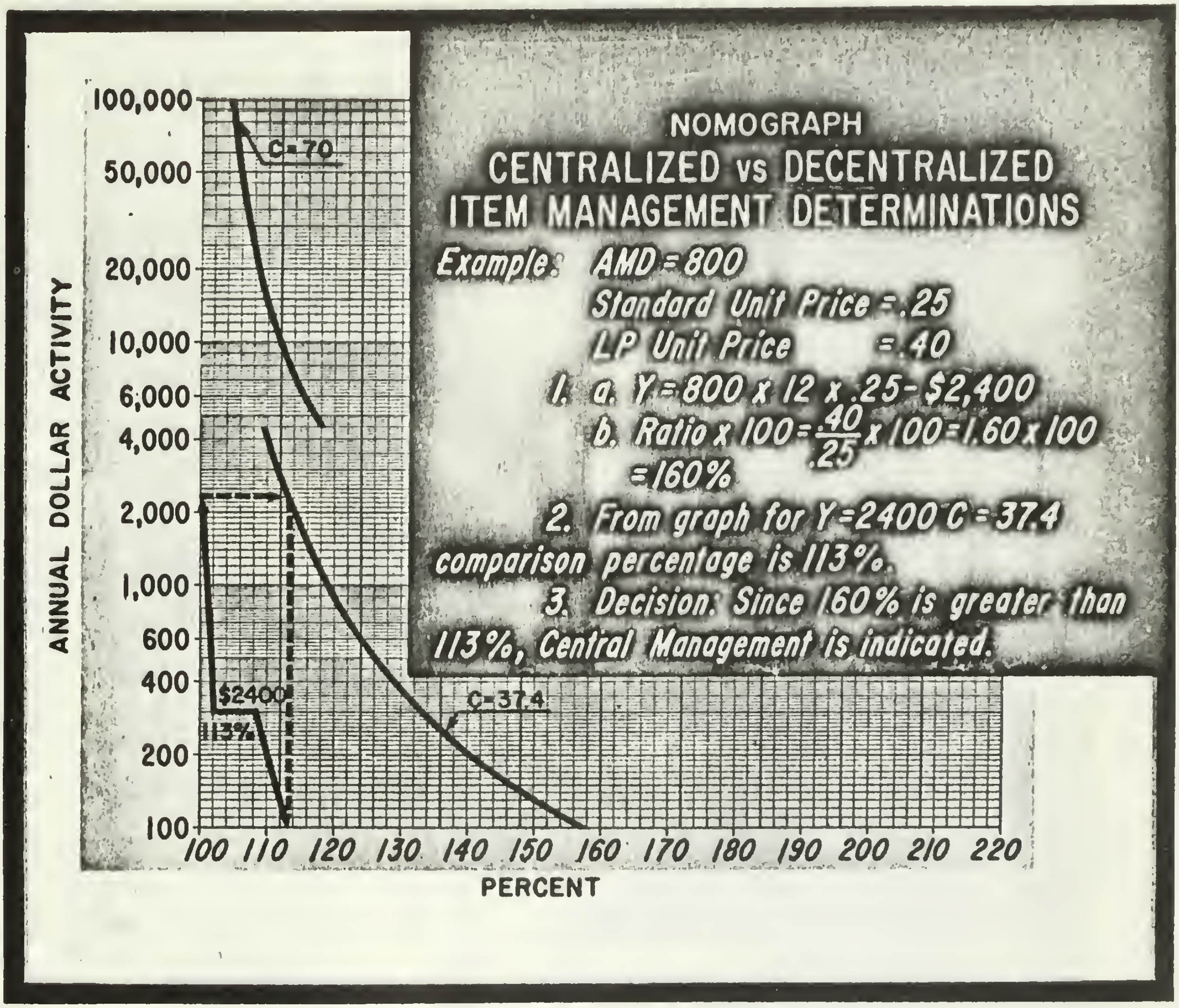

NOMOGRAPH
CENTRALIZED vs DECENTRALIZED
ITEM MANAGEMENT DETERMINATIONS
Example: AMD = 800
Standard Unit Price = .25
LP Unit Price = .40
1. a. Y = 800 x 12 x .25 - $2,400
b. Ratio x 100 = .40/.25 x 100 = 1.60 x 100 = 160%
2. From graph for Y = 2400 C = 37.4 comparison percentage is 113%.
3. Decision: Since 160% is greater than 113%, Central Management is indicated.
ANNUAL DOLLAR ACTIVITY
100,000
50,000
20,000
10,000
6,000
4,000
2,000
1,000
600
400
200
100
C=70
C=37.4
$2400
113%
100 110 120 130 140 150 160 170 180 190 200 210 220
PERCENT

FIGURE 2

PROCUREMENT CYCLE

SAFETY LEVEL + PROCUREMENT LEAD TIME = REORDER POINT

SAFETY LEVEL + PLT + PROCUREMENT CYCLE = PROCUREMENT OBJECTIVE

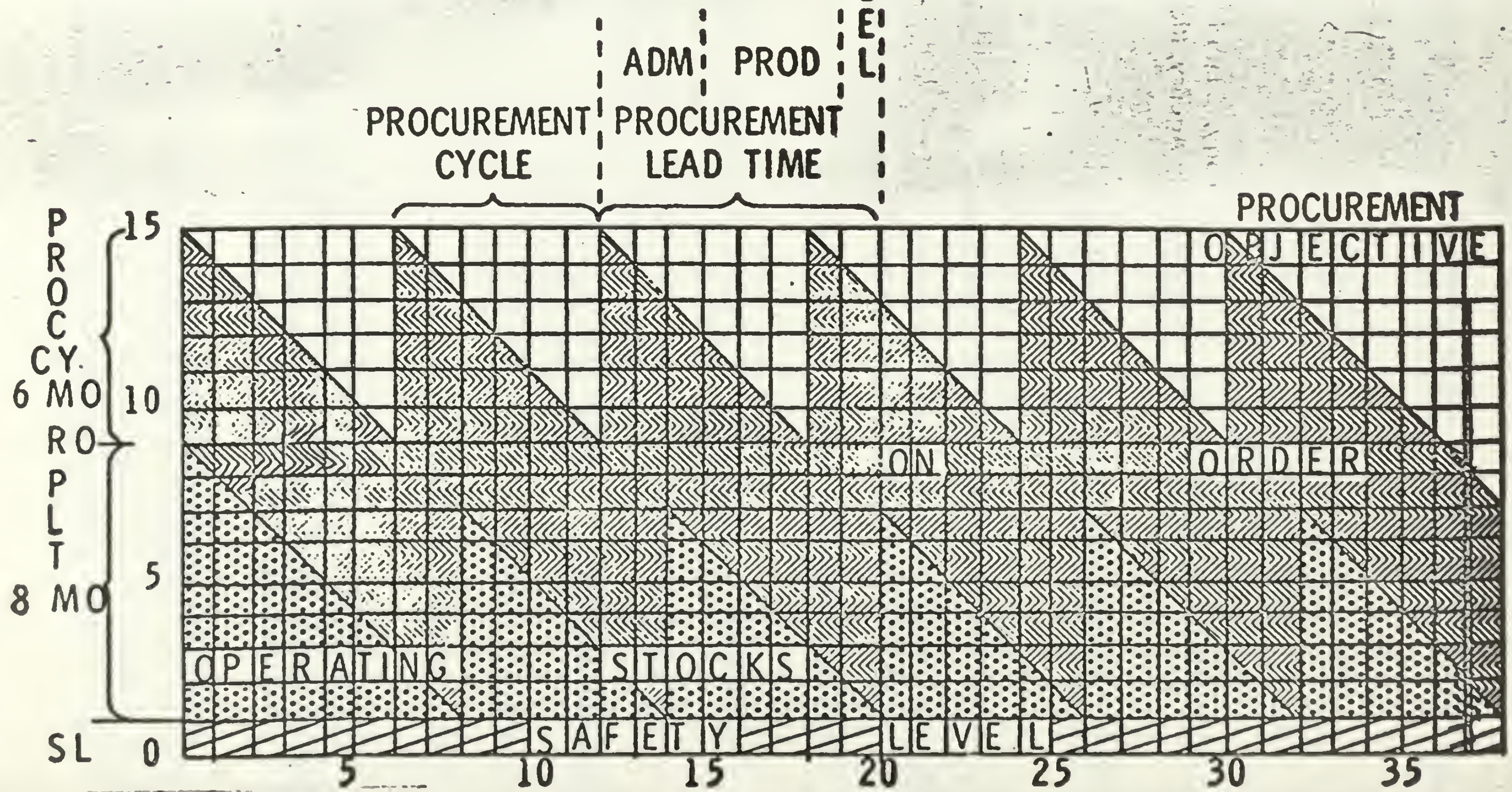


FIGURE 3

PROCUREMENT CYCLE

BIBLIOGRAPHY

Application of Mathematical/Statistical Rules at the Ship's Parts Control Center (A Report to Navy Inventory Managers given at NSD Mechanicsburg, June 1960).

Arthur D. Little Inc. Work Memorandum Number 63, 10 April, 1963.

Ball, S. M. Capt., SC, USN. "Automation in the Navy Supply System," Bureau of Supplies Accounts Newsletter, XXVI (April, 1963).

Brown, Robert G. Smoothing, Forecasting, and Prediction. Englewood Cliffs: Prentice-Hall, Inc., 1963.

Brown, Robert G. Statistical Forecasting for Inventory Control. New York: McGraw-Hill Book Company, Inc., 1959.

Chief, Bureau of Supplies and Accounts Letter S 14.5. Subject Locally Managed Items: Information Concerning, 11 April, 1960.

Chief, Bureau of Supplies and Accounts Letter, S 13-33, Supply Management Responsibility for Defense Supply Agency Items, 12 February, 1964.

Defense Supply Agency Material Management System Requirements Study. July, 1963.

Defense Supply Agency Regulation Number 4140.6, Subject Selective Materiel Management Program, 4 September, 1962.

Defense Supply Agency Letter DSAH-OM, Subject: Selective Materiel Management Program, 18 December, 1962.

Department of Defense Instruction 4140.11, Subject: Peacetime Operating and Safety Levels of Supply, 24 June, 1958.

Department of Defense Instruction 4140.7, Subject: Supply, Control, and Positioning of Material, February, 1961.

Electronic Supply Office Internal Instruction 4440.57, Subject: Star Item Management, 4 January, 1963.

Fleet Material Support Office Instruction P 4400.12 A, Subject: Navy Retail Management of Medical, General, Industrial, Automotive, Construction, Packaged Petroleum, and Chemical Items Under Cognizance Symbols "9L," "9G," "KZ," "9A," "9C," and "9W"; Instructions for, 4 October, 1963.

General Information Manual IMPACT, Inventory Management Program & Control Techniques, International Business Machines Corp., 1962.

Haddock, Ira F. RADM(SEL), SC, USN. "Supporting Polaris Complex Costly," Bureau of Supplies and Accounts Newsletter, XXVI (August, 1963).

Harbridge House Inc. Economic Inventory Policy Report Number 2 National Order and Holding Costs of the U. S. Army Signal Supply Agency, 7 March, 1961.

Hitch, Charles J. "The New Approach to Management in the U. S. Defense Department," Management Science, 9:1, October, 1962.

Integrated Navy/Defense Supply Agency Supply Systems, Chief Bureau of Supplies & Accounts Letter, S13.33, 30 July, 1963.

Karr, H. W. "A Method for Estimating Spare Part Essentiality," RAND Paper P-1064, 17 April, 1957.

Memorandum for the Record, Subject: Project 65 Economic Inventory Programs signed Walter Goldfinger, Project 65 Action Officer, 29 December, 1961.

Mills, H. F., CDR, SC,USN. "Military Essentiality," Bureau of Supplies & Accounts Newsletter, XXVI (March, 1963).

"Pattern for Tomorrow. . . This is DSA," Bureau of Supplies & Accounts Newsletter, XXVI Number 2, (February, 1962).

Program 61 Ship's Parts Control Center SPCC Models Extracted from Advanced Logistics Research Division ALRAND Report Number 32, 5 April, 1963.

Ship's Parts Control Center Internal Instruction 4440.285A, Subject: Non-Stocked Items (NSI): Review, Evaluation and Processing of, 30 October, 1961.

Starr, Martin K., and David W. Miller. Inventory Control: Theory and Practice. Englewood Cliffs: Prentice-Hall, Inc., 1962.

U. S. Army Regulation 710-45, Subject: Supply Control Policies and Procedures for Minor Secondary Items & Repair Parts, 15 October, 1962.

Welch, W. Evert. Tested Scientific Inventory Control. Greenwich: Management Publishing Corporation. 1956.

Whitin, Thompson M. The Theory of Inventory Management. Princeton: Princeton University Press, 1957.

Approved for public release; 11-12-76
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